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Farming nomenclature, distribution and diversity of squash (Cucurbita sp) in Burkina Faso

Soumbougma Benoît[1]*, Tiama Djakaridja[2], Ouedraogo Jacques[3] and Bationo-Kando Pauline[1]

[1]Department of Plant Biology and Physiology, Joseph KI-ZERBO University, Ouagadougou, Burkina Faso.
[2]National Center for Scientific and Technological Research, Institute of Environment and Agricultural Research, Ouagadougou, Burkina Faso.
[3]Department of plant production, Ziniaré university centre, Joseph KI-ZERBO University, Ouagadougou, Burkina Faso.

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Agriculture plays a crucial role in managing sustainable food security, necessitating a better understanding and conservation of plant genetic resource diversity. This study aims to establish the nomenclature of squash species (*Cucurbita* species) diversity cultivated by farmers in Burkina Faso. A survey was conducted across 19 provinces, divided into nine regions and two climatic zones. Semi-structured individual interviews were carried out using a random sampling method. The data collected were analyzed descriptively and statistically using EXCEL 2016 and R 4.1.2 software. In total, 16 vernacular names were identified among 14 ethnic groups. The survey also identified three species (*Cucurbita maxima, Cucurbita moschata*, and *Cucurbita argyrosperma*) in the Sudanian zone, and a single species (*Cucurbita maxima*) in the Sudano-Sahelian zone. For the different morphotypes of each species, interviewees primarily used the color of the fruit as a distinguishing factor. Consequently, six, four, and two morphotypes were identified for *C. maxima, C. moschata*, and *C. argyrosperma*, respectively. There is intraspecific variability in all nine regions surveyed. The high value of the equitability index indicates a regular distribution of morphotypes across these regions. Understanding the distribution and genetic variability levels of squash species will facilitate better management of this plant genetic resource.

Key words: Distribution, diversity, squash, *Cucurbita* species, Burkina Faso.

INTRODUCTION

According to FAO (2023), nearly 815 million people worldwide are malnourished. By 2050, the world's population could reach 10 billion, which will result in a significant increase in the number of malnourished people. In Africa, particularly in the southern part of the Sahara, annual cereal production remains low. This decline in production is mainly due to the combined effects of deteriorating climatic conditions and ecosystem degradation (Naeem and Defries, 2009). In the coming years, humanity will face issues related to the availability of food resources due to the ever-growing global population. The decreasing availability of arable land and

*Corresponding E-mail: bsoumbougma@gmail.com.

insufficient water resources, along with the decline in agricultural production, make food security a major concern for Sahelian countries in West Africa (FAO, FIDA, OMS, PAM and UNICEF, 2020; De Bruin et al., 2021).

Agriculture plays an important role in managing sustainable food security. Therefore, agricultural improvement plans and the conservation of phylogenetic resources are necessary. Among these plants, those that are neglected or under-used and referred to as minor or orphan plants hold an important place. Squash is one of these plants, valued for its fruit, leaves, and seeds, which are used in cooking. Squash pulp is rich in water, bioactive nutrients (with 80% β-carotenes), polysaccharides, dietary fiber, pectin, proteins, and minerals. It is also a source of vitamins B6, K, E, A, and C (Ponka et al., 2015). The seeds are rich in lipids and proteins (Loukou et al., 2007). Enhancing the value of squash can contribute to improving food quality. Additionally, squash has many agronomic and economic potentialities. It is well adapted to different agro-ecosystems and cropping systems (Chweya and Eyzaguirre, 1999).

Understanding the distribution and extent of the genetic diversity of species is essential for their conservation and effective use. Hence, this study aims to document the farming practices and assess the biological diversity of squash (*Cucurbita* species) grown in Burkina Faso. Specifically, the objectives are to (i) identify the different species grown, (ii) describe intraspecific variability, and (iii) identify the criteria used by farmers to differentiate squash.

METHODOLOGY

Area of study

The surveyed area covers 19 provinces divided into nine administrative regions and two climatic zones of Burkina Faso. These regions are: (i) the provinces of Noumbiel, Poni, Bougouriba, and Ioba in the South-West region, (ii) the provinces of Kouritenga and Boulgou in the Centre-East region, (iii) the province of Sanguié in the Centre-West region, (iv) the province of Zoundweogo in the Centre-South region, (v) the province of Passoré in the North region, (vi) the provinces of Mouhoun, Kossi, Sourou, Balé, and Solenzo in the Boucle du Mouhoun region, (vii) the province of Kadiogo in the Centre region, (viii) the province of Gourma in the Eastern region, and (ix) the provinces of Houet, Kénédougou, and Tuy in the Hauts-Bassins region. In total, data were collected from 74 villages, of which 48 were in Sudanian climatic zones and 26 in Sudano-Sahelian zones (Figure 1). These villages were identified with the support of the General Directorate for Plant Production of the Ministry of Agriculture.

Ethnobotanical survey

Data for the ethnobotanical survey were collected from November to December 2020 in the areas identified for this study. Semi-structured individual interviews were conducted with 194 squash growers and traders randomly selected.

Each grower was interviewed in his own field to enable him to name and identify the different cultivars. Traders were interviewed directly at their place of business. The questionnaire was administered to the interviewees in their native language. The heads of the technical support zones and village development advisers, who had a good command of local languages and were familiar with the species, provided assistance for data collection in each village.

The questionnaire administered to the interviewees focused on (i) plant characteristics, that is, a description of the organs of the plant, (ii) the differences between cultivars, (iii) the differentiation criteria of the species, and (iv) an attribution of the different cultivars (morphotypes) encountered to their respective species. Direct observations in growers' fields were carried out to describe existing variability and identify grown species using a species identification key established by the flora of Benin.

The equipment used for the field survey consisted mainly of a survey form for collecting data from growers, a GPS device for taking geographical coordinates of the villages, a camera for taking images, and a key for species identification.

Data analysis

The data collected were entered and processed (coded) using Excel 2016 software. Descriptive analyses were used to calculate frequencies, with results presented in the form of graphs or tables. Specific and varietal diversity, as well as their abundance, were determined by calculating diversity indices. The Shannon diversity index (H) combines the number and regularity of the species or cultivars considered. Shannon's equitability (E) measures the ratio of observed diversity to maximum diversity, where high regularity indicates high abundance or diversity (Magurran, 1988). Simpson's diversity index (Is) measures the probability that two individuals randomly selected from a sample belong to the same species or cultivar (Simpson, 1949). Sorensen's similarity index expresses the degree of similarity of morphotypes between different areas. Diversity indices were calculated and their significance tested using R 4.3.1 software. QGIS 10.8 software was used to map the survey areas based on the geographical coordinates recorded in the field.

RESULTS

Nomenclature of local squash and criteria for species identification

In total, a census of 16 vernacular names was recorded within the 14 ethnic groups found in the 19 provinces surveyed (Table 1). The names varied from one ethnic group to another, but not within the same group, with the exception of the Gourounsi and Lobi ethnic groups. Farmers use the morphological features of the fruit, leaves, seeds, flesh, and stalk to identify them. The majority of growers (94.33%) used the features of the fruit, followed by those of the leaf (69.59%), the flesh (12.89%), and finally the features of the seeds and stalk, with 7.73 and 4.12% of the interviewees respectively.

However, within each species, only the features of the fruit (color and shape) were used to identify morphotypes.

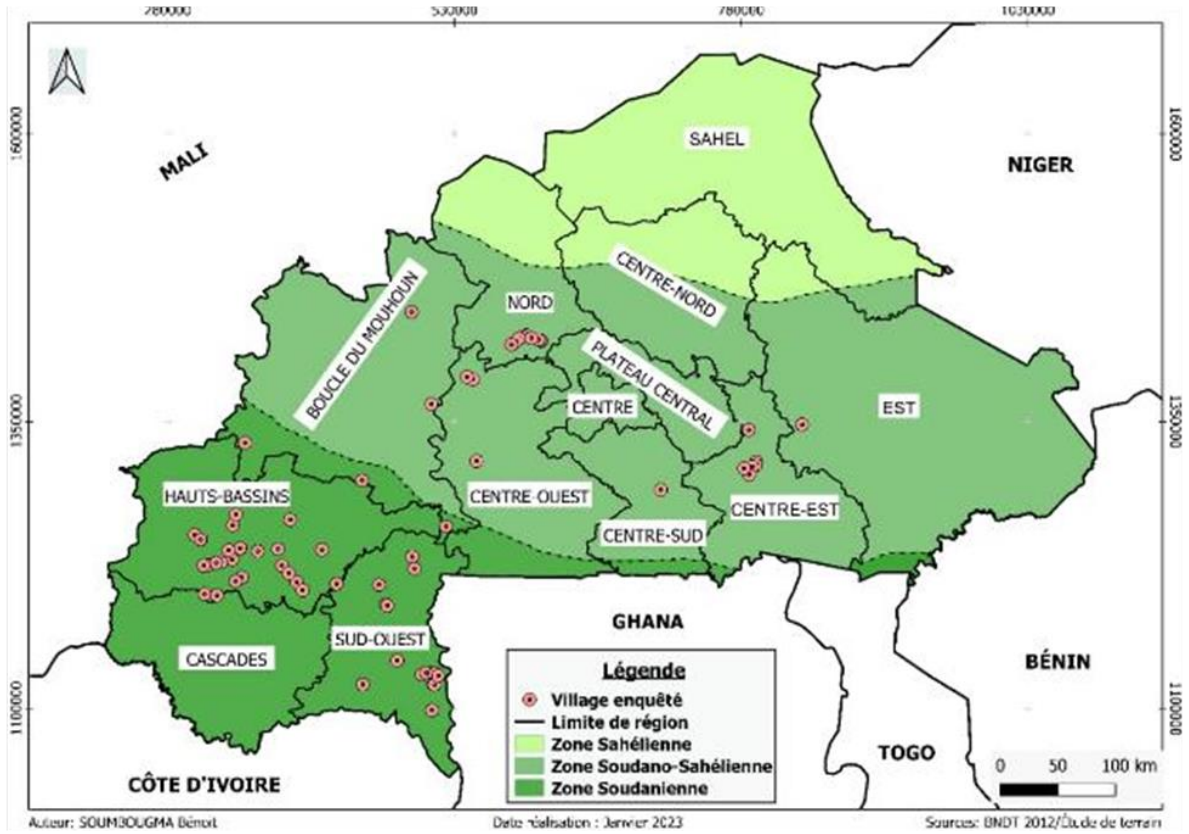

Figure 1. Burkina's climatic areas and location of the surveyed sites.

Table 1. Squash names in the 14 local languages.

Ethnie	Name	Specific names	Meaning of specific names
Birifor	*Yow*	*yow sala*	Squash with dark green fruit
		yow djion	Squash with red or orange fruit
		yow pla	Squash with white or light-yellow fruit
		yow fule	Light green-fruited squash
		yow doré	Yellow-fruited squash
Bobo	*Kamani*	*Kamani pènè*	Squash with red or orange fruit
		Kamani fouro	Squash with white or light-yellow fruit
		Kamani binkênèma	Light green-fruited squash
		Kamani noufoigama	Yellow-fruited squash
Bwamu	*Bouhoun*	*Bouhoun diabir*	Squash with dark green fruit
		Bouhoun diamii	Squash with red or orange fruit
		Bouhoun diafouu	Squash with white or light-yellow fruit
		Bouhoun yisiédia	Light green-fruited squash
Dafi	*Guée*	*Guée fiman*	Squash with dark green fruit
		Guée wulènma	Squash with red or orange fruit
		Guée djêman	Squash with white or light-yellow fruit
		Guée binkênèma	Light green-fruited squash

Table 1. Contd.

Dagara	*Yow*	*Yow saoula ou sonla*	Squash with dark green fruit
		Yow siiyè	Squash with red or orange fruit
		Yow pla	Squash with white or light-yellow fruit
		Yow fule	Light green-fruited squash
Dioula	*Guée*	*Guée fiima*	Squash with dark green fruit
		Guée wulèma	Squash with red or orange fruit
		Guée guèma	Squash with white or light-yellow fruit
Gourounssi	*Goon, Gaam*	*Goon nabiou*	Squash with dark green fruit
		Goon nassion	Squash with red or orange fruit
		Goon napoua	Squash with white or light-yellow fruit
Lobi	*Infaar, Djodjoun*	*Infaar dabri*	Squash with dark green fruit
		Infaar dablo	Squash with white or light-yellow fruit
		Infaar datour	Light green-fruited squash
		Infaar dadour	Yellow-fruited squash
Mossi	*Yogré*	*yog sablga*	Squash with dark green fruit
		yog miougou	Squash with red or orange fruit
		yog peele	Squash with white or light-yellow fruit
		yog rondo	Yellow-fruited squash
Samo	*Dji*	*Dji tchi*	Squash with dark green fruit
		Dji tannin	Squash with red or orange fruit
		Dji fou	Squash with white or light-yellow fruit
Toussian	*Borondjegué*	*Borondjegué schiir*	Squash with dark green fruit
		Borondjegué shioun	Squash with red or orange fruit
		Borondjegué prèii	Squash with white or light-yellow fruit
Djan	*anfaouw*	*ambere*	Squash with light or dark green fruit
		djodjo	Squash with red, yellow or orange fruit
Gan	*Yéegué*	-	-
Sambla	*Bonguè*	-	-

Depending on the colour of the fruit, four morphotypes have been identified, called "*yog miougou*" in Mooré and "*yow zièe*" in Dagara or "*Bouhoun diamii*" in *Bwamu* meaning red or orange squash, "*yog sablga*" in *Mooré* and "*yow saoula*" in *Dagara* or "*Goon nabiou*" in *Gouruonsi* meaning dark green squash, "*yog peele*" in *Mooré*, or "*Kamani fouro*" in *Bobo* and "*yow pla*" in *Dagara* meaning white squash and "*yog rondo*" in *Mooré*, "*Infaar dadour*" in *Lobi* and "*yow doré*" in *Dagara* which means yellow-fruited squash. In reference to the shape of the fruit, two morphotypes have been identified, called "*yog guilga*" in *Mooré* and "*yow gmaan*" in *Dagara*, meaning squash with round fruit, and "*yog soolé*" or "*yog woglé*" in *Mooré* and "*yow woor*" in *Dagara*, meaning squash with cylindrical or allogated fruit.

Distribution of the species of squash identified in growers' fields

Based on an identification key (flora of Benin, Paris, 2016), three species out of the five grown worldwide were identified in growers' fields. These are *Cucurbita maxima, Cucurbita moschata* and *Cucurbita argyrosperma.*

Table 2. Diversity of squash species grown by province.

Region	Province	Number of species	Species found
Sud-Ouest	Bougouriba	3	*C. maxima, C. moschata* and *C. agyrosperma*
	Ioba		*C. maxima, C. moschata* and *C. agyrosperma*
	Poni		*C. maxima, C. moschata* and *C. agyrosperma*
	Noumbiel		*C. maxima, C. moschata* and *C. agyrosperma*
Haut-Bassins	Houet	3	*C. maxima, C. moschata* and *C. agyrosperma*
	Kénédougou		*C. maxima, C. moschata* and *C. agyrosperma*
	Tuy		*C. maxima C. moschata* and *C. agyrosperma*
Boucle du Mouhoun	Solenzo	3	*C. maxima, C. moschata* and *C. agyrosperma*
	Balé		*C. maxima, C. moschata* and *C. agyrosperma*
	Kossi	1	*C. maxima*
	Sourou		*C. maxima*
	Mouhoun		*C. maxima*
Centre	Kadiogo	2	*C. maxima* and *C. moschata*
Centre-Est	Kouritenga	1	*C. maxima*
	Boulgou		*C. maxima*
Est	Gourma	1	*C. maxima*
Nord	Passoré	1	*C. maxima*
Centre-Oest	Sanguié	1	*C. maxima*
Centre-Sud	Zoundwéogo	1	*C. maxima*

By province, the species are unevenly distributed, with the number encountered varying from one to three. The frequency of the identified species varied from 54.12 to 100%, with the most common species being *C. maxima* (100%) and *C. moschata* (62.37%). *C. maxima* were found in all the provinces and all the villages covered by the study. *C. moschata* and *C. argyrosperma* were only found in the provinces of the South-West and Haut-Bassins regions. In the Boucle du Mouhoun region, they were only found in the Balé and Solenzo provinces (Table 2).

Intraspecific variability examined in the fields of the interviewed growers

Intraspecific variability of C. maxima

This species is composed of morphotypes that are generally differentiated by the shape, size, and color of the fruit at maturity. Six morphotypes were identified based on mature fruit color (Figure 2). These colors are red (57.7%), light green (54.6%), yellow (50%), white (54.6%), dark green (18%), and green with spots (24.7%). The flesh of these fruits is bright red, and the seeds vary in color from yellow to orange. The leaves of this species are broad and green (Figure 3).

Intraspecific variability of C. moschata

The fruits are globose to ovoid or cylindrical in shape with small warty protuberances, sometimes covered with spots and streaks. Based on their color, four morphotypes were identified (Figure 4): mottled green fruit morphotypes (49.6%), dark green fruit morphotypes (34.7%), yellow fruit morphotypes (28.1%), and orange fruit morphotypes (25.6%). These fruits have yellow or orange flesh (Figure 5). The stalk is ribbed and widened at the apex. The leaves have broad blades that are sometimes mottled silver and slightly lobed (Figure 5). The seeds are brown and tapered.

Intraspecific variability of C. argyrosperma

This species is characterized by small, white or green fruits with stripes (Figure 6). At maturity, the exocarp

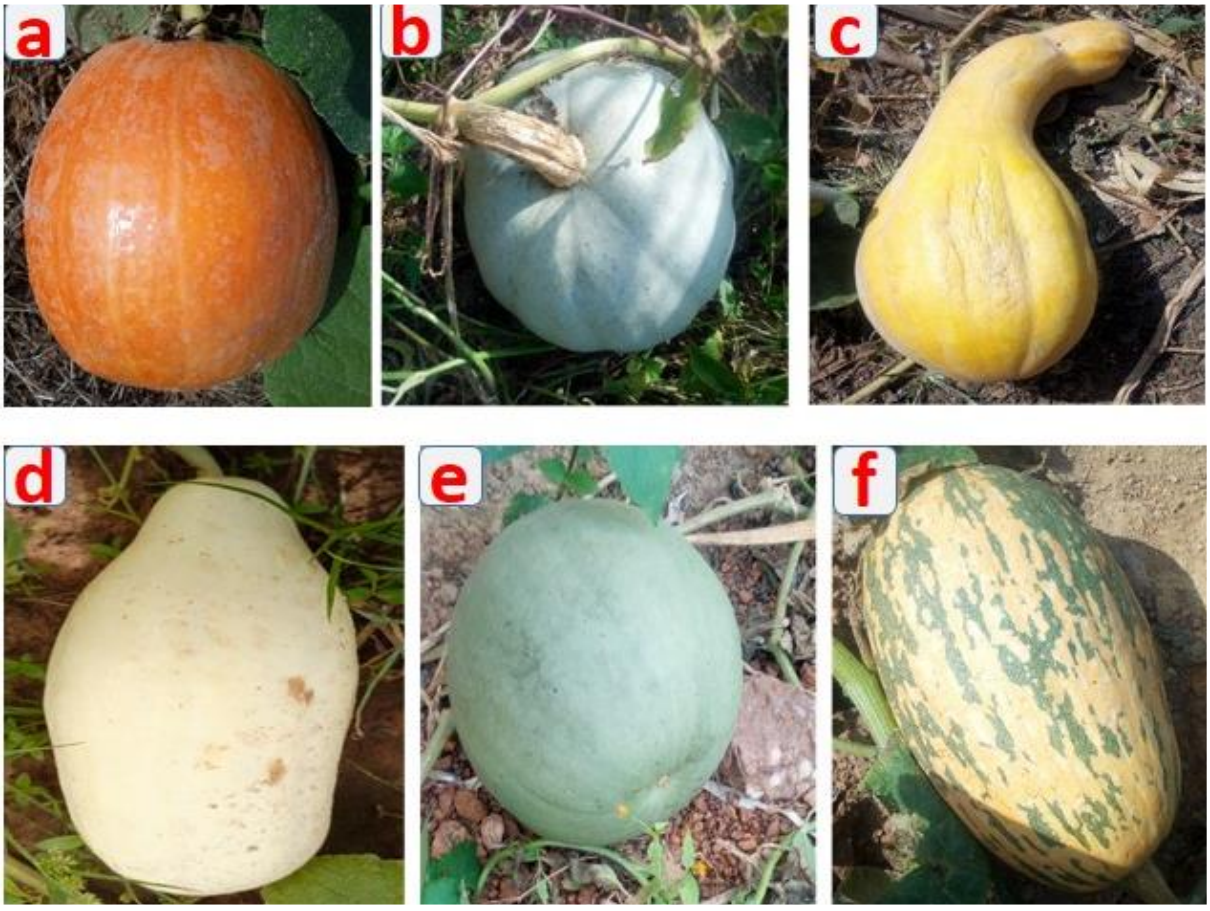

Figure 2. Variation in the colour of *C. maxima* fruit found in the fields of the growers surveyed, a: orange; b: light green; c: yellow; d: white; e: dark green and f: green with spots.

Figure 3. Some organs of *C. maxima*: a: leaf; b: cross-section of the orange-fleshed fruit; c: seeds.

lignifies and becomes dry and very hard. The flesh of this species is fibrous and white or yellow in color (Figure 7). The leaves are slightly smaller than those of the other two species and are slightly to deeply lobed, often mottled with white (Figure 7). The stalk is ribbed and expands at the point of attachment to the fruit.

Figure 4. Variation in the colour of *C. moschata* fruit found in growers' fields: a: green with spot; b: dark green; c: yellow d: orange.

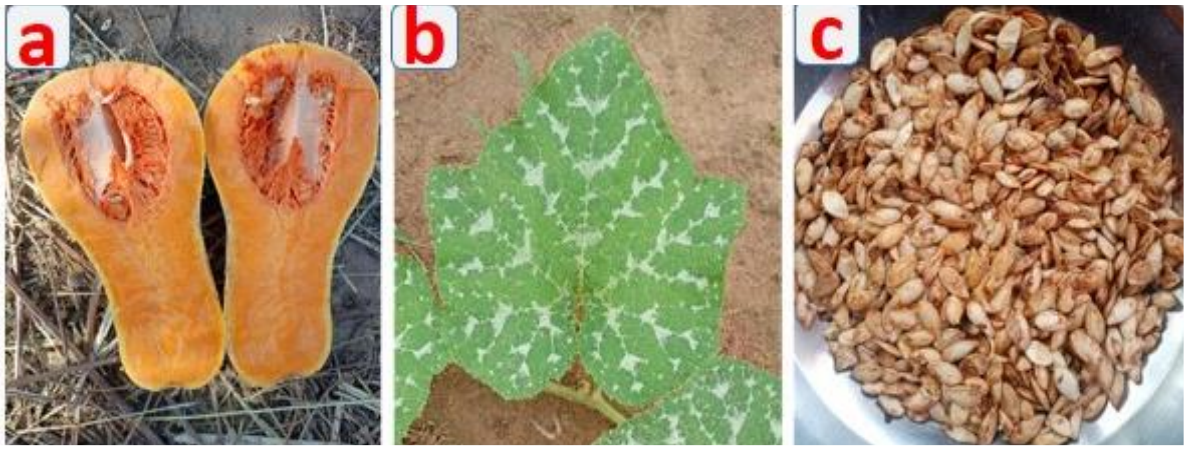

Figure 5. Organs/identifying parts of C*. moschata*; a: section of orange-fleshed fruit; b: marbled leaf; c: seeds.

Figure 6. Variation in fruit colour of *C. argyrosperma* found in farmers' fields, a: white; b: green with stripes.

Figure 7. Organs or parts of *C. argyrosperma*: a: leaf, b, c: different colours of flesh; d: seeds.

Table 3. Cultivar diversity in the study area.

Region	Species	Morphotype	1-D	E
B. Mouhoun	3	11	0.6481	0.8395
Centre	2	7	0.7188	0.6311
Centre-Est	1	2	0.5005	0.3560
Centre-Ouest	1	5	0.7533	0.7661
Centre-Sud	1	4	0.7000	0.6577
Est	1	1	0.6889	0.1882
Hauts-Bassins	3	12	0.6274	0.8331
Nord	1	6	0.7012	0.7274
Sud-Ouest	3	13	0.6339	0.8443
P-value	0.26	1	0.004	0.008

1-D: Indice de Simpson; E: Equitabilité.

Diversity of morphotypes identified by province and region

The non-parametric Kolmogorov-Smirnov test indicated a highly significant difference in the distribution of morphotypes across regions (Table 3). Generally, all regions showed a high Simpson index, indicating diversity in squash morphotypes. The equitability index showed greater regularity of squash morphotypes in the South-West, Hauts-Bassins, and Boucle du Mouhoun regions, which have the highest number of species and morphotypes. In contrast, the Eastern region, despite having a low number of morphotypes, exhibited the lowest Equitability index, indicating an irregular distribution of morphotypes in this region.

Similarity index (Table 4) calculated between different regions ranged from 14.28 to 86.96%. Accessions from the Boucle du Mouhoun and Hauts-Bassins regions showed the highest similarity (86.96%) followed by accessions from the Boucle du Mouhoun and South-West regions (83.34%). The lowest similarity was observed between the East and South-West regions.

DISCUSSION

Squash (*Cucurbita* spp.) are well-known among the general public in the two climatic zones of Burkina Faso where they are cultivated. The diversity of vernacular names within each ethnic group attests to the familiarity of this genetic resource in the surveyed provinces. Similar to other traditional crops, naming criteria are based on the morphological features of the fruit and leaves, which are the organs of interest (Bambara et al., 2011; Jiro et al., 2011; Bationo-Kando et al., 2016; Ouedraogo et al., 2023). The *Cucurbita* spp. found with farmers (*C. maxima, C. moschata*, and *C. argyrosperma*) are commonly grown worldwide. However, they are unevenly distributed across different regions and surveyed provinces. While *C. maxima* are cultivated in all villages in the study area, *C. moschata* and *C. argyrosperma* are found only in the Sudanian zone of the country. This distribution can be attributed to growers' preferences for specific species or cultivars, which has been observed for various vegetable leaves and fruits grown in Burkina Faso (Bationo-Kando et al., 2015;

Table 4. Coefficients of similarity (in %) between the different regions.

Biotope	B. Mouhoun	Centre	Centre-Est	Centre-Ouest	Centre-Sud	Est	Hauts-Bassin	Nord	Sud-Ouest
B. Mouhoun	100								
Centre	66.67	100							
Centre-Est	30.77	44.44	100						
Centre-Ouest	50	33.33	85.71	100					
Centre-Sud	53.34	72.73	66.67	66.67	100				
Est	16.67	25	66.67	33.33	40	100			
Hauts-Bassin	86.96	63.16	28.57	35.29	50	15.38	100		
Nord	47.06	61.54	75	72.73	80	28.57	55.56	100	
Sud-Ouest	83.34	70	40	55.56	47.07	14.28	80	63.15	100

Ouedraogo et al., 2023).

Furthermore, the specific growing areas of *C. moschata* and *C. argyrosperma* could be influenced by the dietary habits and cultural practices of the local populations. According to Traoré (2007), populations in western Burkina Faso share similar dietary habits and cultural closeness, which may influence crop preferences. Additionally, differences in adaptability or preferences of these species to soil and climate conditions could also play a role. Within the *Cucurbita* spp., there are overlapping traits and adaptations, making it challenging to distinguish between *C. argyrosperma* and *C. moschata* as distinct species (Pangalo, 1930; Cutler and Whitaker, 1956).

The intraspecific variability, characterized by the existence of several morphotypes per species, can be explained by both farming management practices that promote significant gene flow and an allogamous reproduction method favoring genetic mixing between morphotypes. This variability varies among species, with *C. maxima* exhibiting the highest, followed by *C. moschata* and then *C. argyrosperma*. According to Ferriol and Pico (2008), *C. maxima* are one of the most diverse species after *C. pepo*. Research by Ferriol et al. (2004) has highlighted the extensive diversity of *C. maxima* in terms of morphological and molecular characteristics, with fruits varying significantly in size, shape, color, and flesh. Many cultivars of *C. maxima* have also been selected in secondary centers of diversity, including those in Europe.

C. moschata also displays considerable diversity, with ripe fruits typically varying less in external color (often buff, sometimes yellow or dark green), but consistently exhibiting deep orange flesh, contributing to its distinct aroma (Paris, 2007). Studies indicate that *C. moschata* likely ranks next to *C. maxima* in terms of variability within the genus (Andres, 2004; Ferriol and Pico, 2008; Gong et al., 2013).

On the other hand, *C. argyrosperma* shows less diversity compared to the other two species, as confirmed by previous research (Lebeda et al., 2007). The predominance of *C. maxima* across several villages in Burkina Faso may reflect its adaptability to diverse soil and climate conditions nationwide. While *C. moschata* and *C. argyrosperma* thrive in hot and humid environments (Whitaker and Davis, 1962), *C. maxima* demonstrate adaptability across a wider ecological range (Haudricourt, 1959; Lira-Saade, 1995).

Conclusion

This demonstrates distinct species diversity between the Sudanian and northern Sudanian zones. The western regions, benefiting from more favorable climatic conditions, exhibit greater species richness. *C. maxima* emerge as the most diversified species, found across all surveyed provinces. The research successfully established the correspondence between traditional vernacular names and the Latin names of recorded species, facilitating better dissemination of squash species information.

Based on these findings, we recommend exploring the cultivation of *C. moschata* and *C. argyrosperma* in the Sudanian zone to assess their adaptability and promote wider use of squash among local populations. Additionally, our work supports *ex-situ* conservation efforts and lays the groundwork for future studies including agro-morphological, molecular, and biochemical characterization of these species.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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